corresponds to its one degree of freedom on Boltzmann's theory of partition of energy, I am afraid the amount of energy of this kind on each particle is hardly sufficient to account for any observable phenomenon. That it may, however, be much greater seems justified by the failure of this theory, so far as is known, in other cases, and this must be my excuse for calling attention to what seems certainly a *vera causa* for structures and actions in matter of a size comparable with the heat vibrations in the ether, even though the amount of this cause may, when fully investigated turn out to be so small as to be insufficient to produce observable effects.

GEO. FRAS. FITZGERALD.

REPORT OF THE MALARIA EXPEDITION TO SIERRA LEONE.

FOLLOWING close on the "Instructions for the Prevention of Malaria," the Liverpool School of Tropical Medicine have issued the report of the malaria expedition sent out to Sierra Leone by that body in August last. Their objects, as stated in the report, were :—

(1) To find one or more species of insects hospitable to the human Hæmamœbidæ on the West Coast of Africa.

(2) To study the bionomics of these insects, with a view to suggesting better modes of prevention of malarial fever than those hitherto known to us.

The terminology adopted is that used by Major Ross in consultation with Prof. Herdman, already noticed in NATURE (August 3, 1899). It is proposed to abolish the word mosquito, and use the old English equivalent, gnat, as there is no difference between the two, and because the terms malaria and malarial fever no longer hold—they propose the term hæmamœbiasis, or gnat fever.

The genus Anopheles was chiefly looked for, because these had been shown to be concerned in the transference of the parasite. In the barracks at Wilberforce, Sierra Leone, 25 per cent. of the soldiers suffered from all three forms of malaria or gnat fever. All the gnats caught in the barracks were *Anopheles costalis* except one, and out of 109 of those examined, parasites were found in 27.

Some experiments on feeding Anopheles on a patient with *H. malariae* gave positive results, several young zygotes being found in the gnat. These gnats were caught in a building where there were no fever patients, and numbers of them had been examined and found free from parasites. When, however, Anopheles bred from the larvæ and kept in test tubes were applied to the skin of a patient, they were found not to feed copiously, and negative results, as regards zygotes, were obtained on dissecting them. It is suggested that the explanation of the failure was the non-fertilisation of the females ; it seems that the female gnat requires blood for the nutrition of the eggs. If the ova are not fertilised, the blood is possibly evacuated without some digestive process being performed which may be necessary to the vitality of the zygotes.

Measures of precaution against the bites of gnats, and measures for reducing their numbers, are discussed in the chapter on prevention. It is remarked that neither Europeans nor natives made any effort to keep down the numbers of gnats, which constitute a very serious pest in Sierra Leone, as they do in all tropical towns. Both this report and the "Instructions for the Prevention of Malaria" should be invaluable to residents abroad, as indicating how they may protect themselves from the annoyance from gnats, and from the evil results that may arise from their "bites."

Experiments were instituted with a view to destroying the adults or larvæ, and to prevent the insects from breeding. It was not always possible to discover the breeding pools of the Anopheles infecting a particular spot ; for instance, none could be found at Wilberforce, the nearest pools where larvæ were found being nearly a mile away. Dr. Fielding Ould tried experiments with tar, and found the film on the surface of the pool lasted longer than a film of kerosene oil ; while both killed the larvæ and prevented them from hatching so long as the film lasted.

In the addenda are some good micro-photographs of both zygotes and blasts from the gnat.

JOSEPH BERTRAND.

AMONG the heavy losses which science has suffered during the past few months, few will be the subject of such universal regret as the death, on April 3, of M. Joseph Bertrand. The loss will be felt, not only by mathematicians, but also by the great body of scientific men with whom Bertrand was brought into contact in his capacity of life-secretary of the Paris Academy of Sciences.

Joseph Bertrand was born at Paris in 1823, and at an early age commenced his mathematical studies under the guidance of his father, who had been a pupil of the Ecole Polytechnique. Subsequently Bertrand entered the Collège de St. Louis, and at the age of eleven he succeeded in passing the examination for entrance into the École Polytechnique, although it was not till six years later that he actually entered the college, when he headed the list of candidates. As a boy, Bertrand would nowadays be styled an "infant prodigy," by analogy with the youthful musicians who created such a *furore* at London concerts a few years ago ; and it is interesting to learn from M. Maurice Lévy that this title (*enfant prodige*) was actually bestowed on him by the scientific men who welcomed Joseph as a young colleague at an early stage of his existence. The analogy between music and mathematics seems, moreover, to have suggested itself to M. Jules Lemaitre, Director of the French Academy, who remarks that such precocity of genius is sometimes found in mathematics and in music, but is never seen in literature. We find Bertrand publishing a paper on the theory of electricity in 1839, when he must have been about sixteen years old, and it is hardly surprising in view of this to learn that his precocity amazed his masters. In 1841 he wrote papers on indeterminate forms, Jacobi's theorem and differential equations, and from that time onward he was fairly launched on his career as a writer of mathematical papers, his output being five papers in 1842 and seven in 1843. But whereas most of the young musical *débutants*, to whom reference has just been made, have enjoyed only ephemeral reputations, and have exhausted their energies in their premature efforts to an extent which must have prejudiced their future careers, Bertrand succeeded in achieving all that was predicted of him ; he showed no diminution of energy in advancing years, and, moreover, to judge from all accounts, he developed into a good man of business, a quality which is commonly regarded by "the general public" as incompatible with being a genius.

In 1842 he had a narrow escape from being killed in a railway accident near Meudon. In company with his brother, Alexandre Bertrand, now distinguished as an archæologist, he had gone to Versailles to see the fountains, and on the return journey the accident occurred in which Admiral Dumont d'Erville was killed. Both of the Bertrand brothers suffered, Joseph losing the bridge of his nose—a misfortune which disfigured him for life—while Alexandre's leg was fractured. Joseph rescued his brother by dragging him through "the skylight," the carriage doors being locked. A few months later he

married the sister of one of the injured, a Mademoiselle Acloque. At the Polytechnique, Bertrand acquired a knowledge of mining, and on leaving he became an inspector of mines. He was subsequently appointed professor at the Lycée St. Louis.

In March 1844 he became teacher of analysis (*répétiteur d'analyse*) in the École Polytechnique; from 1847 to 1851 he was examiner for admission to the same institution, which raised him to the rank of professor of analysis in 1856, a post which he held till 1895, just after he had completed his jubilee as a member of the teaching staff, an event which was commemorated on May 27, 1894, by a committee of his old students, who presented him with a medal engraved by Chaplain. In 1847 he was appointed deputy professor to Biot in the department of physics and mathematics at the Collège de France, and on the death of Biot, in 1862, he was appointed to the chair. From then up till 1890 he lectured regularly, with the exceptions that his work was taken by Darboux in 1867, by Maurice Lévy in 1874-76 and 1878-85, by Laguerre in 1885-86; since 1890 Marcel Deprez has acted as his deputy. We have it on the authority of M. Gaston Paris, that his first course of lectures was on a comparative study of the theories according to which geometers had attempted to account for capillary phenomena, his latest lectures being on electricity, thermodynamics and theory of errors. From 1858 to 1862 he was professor of higher mathematics at the École Normale Supérieure, and he also is stated to have held a professorship of special mathematics in the Lycée Napoléon. In 1856 Bertrand was elected a member of the Académie des Sciences at the early age of thirty-four, in place of Sturm; and on the death of Élie de Beaumont, in 1874, he was elected permanent secretary, in which office he had Berthelot as a colleague. He was made officer of the Légion d'Honneur in August 1867, and commander in December 1881. In 1884 he succeeded Jean Batiste Dumas in the French Academy.

Bertrand's larger works—namely, his "Traité d'Arithmetique," published in 1849; his "Traité d'Algèbre," published in 1856; and his "Traité du Calcul differentiel et integral," brought out during the years 1864-70—are accepted as standard treatises by mathematicians in all countries, the last named of the three being perhaps the most widely read of all. His treatise on Arithmetic contains, for the first time, a clear definition of incommensurable quantity. His treatise on the Calculus contains a large number of geometrical applications embodied in his divers memoirs; and special mention may also be made of his exposition of the theory of functional determinants and the close and useful relation which he established between these determinants and the simple derived function of one variable. It is greatly to be regretted that the manuscript of the third volume of this work was destroyed in a fire. A similar misfortune befel the manuscript of his original treatise on Thermodynamics, completed in 1870. In this case, however, the loss has been repaired by the publication of a book on the same subject at a later date, based on a course of lectures given at the Collège de France. Those who have grappled with such a subject as thermodynamics will appreciate his naïve observation that he has not attempted to make a complete treatise, and that he has only expounded what he has understood. But, as M. Lévy justly goes on to remark, on those points which he pretends not to have understood, notably on irreversible phenomena and the application of the Second Law to bodies of non-uniform temperature, he has made a series of critical remarks of great importance, which have already borne fruit. This treatise, moreover, is remarkably rich in illustrative examples all more or less original, those dealing with saturated vapours coming well within the range of *practical* applications. Other works emanating from his pen are an edition of Lagrange's "Mécanique analytique," with copious notes, and a small volume of lectures on electricity, in which Bertrand gives the true origin and reason of Faraday's notion of "electric flux," although, being a mathematician, he naturally favoured the rigorous methods of Ampère, for whom he expressed great admiration.

Passing from these standard treatises to the numerous papers published in scientific journals, a glance down the list of these shows that, from the outset, Bertrand devoted his attention largely to applied mathematics, and to those portions of pure mathematics required in the solution of problems in applied mathematics. His early papers deal chiefly with the differential and integral calculus, differential equations, the calculus of variations, analytical mechanics, and in particular the integration of the equations of dynamics. His papers on the theory of surfaces, dating from 1843, on the principle of similitude in mechanics, on the propagation of sound and on capillary phenomena, are among the best known of his minor writings. After 1864, we find him writing biographical memoirs, commencing with Copernicus, Tycho Brahé and Fresnel, and followed up in later years with Comte, Lavoisier, D'Alembert (1889) and Pascal (1890). In 1868, Bertrand commenced a series of papers on hydrodynamics; flight of birds came under his "ken" in 1871, and in the same year he turned his attention to lunar theory. In the three years 1871-73, he contributed quite a number of papers dealing with electricity and magnetism, including the mutual action of currents, &c. In the period 1874 to 1883, the subjects treated included the sun, figure of the earth, electricity and magnetism, electric transmission of power, the Foucault pendulum, the theory of probability. Probability was always a favourite subject with Bertrand. The numerous pitfalls connected with the solution of problems, the remarkable power of prediction which the theory appears to afford, had a great fascination for him, and many were the courses of lectures which he delivered on this subject, not only at the Collège de France, but even in the less advanced classes at the École Polytechnique, where the subject was introduced by him chiefly in connection with its bearing on astronomy and the applied sciences, such as civil and military engineering.

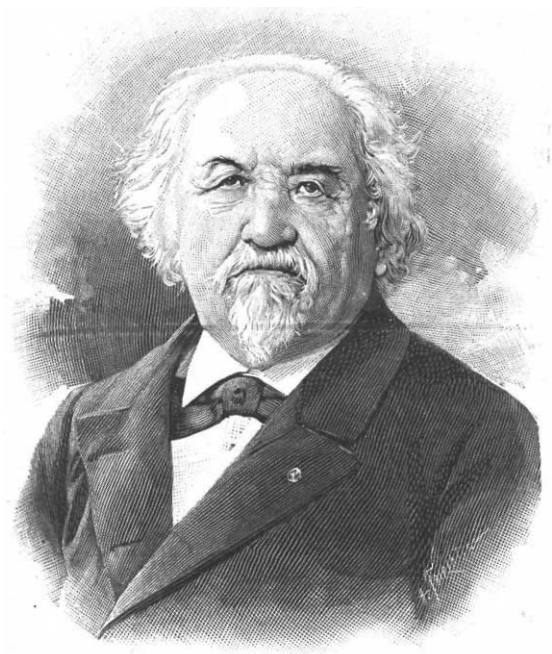
We have spoken, too, of Bertrand's papers on Foucault's pendulum. How far Foucault owed the success of this and his other discoveries to the influence of Bertrand may be judged from M. Lévy's own words. Nearly at the beginning of his (Bertrand's) career, when he was but a mere professor at the Lycée, he discovered Foucault, became attached to him, helped him with the mathematical science which Foucault was lacking, contributed thus to his discoveries without in any way thrusting himself forward; and afterwards, hardly had he been elected into the Academy of Sciences, before he pressed forward the candidature of the great physicist, then little known or unappreciated, against the opposition of many of the highest authorities of that time—a contest which has remained famous. The struggle was not without its risks, nor the success without its honour. One vote turned the scale. But the Institut de France added one more man of genius to its scientific roll.

By the end of 1883 Bertrand had written about 121 papers. Many of these were published in the *Comptes rendus*; others, mostly written in a lighter style and oftentimes with a vein of irony running through them, appeared in the *Revue des deux Mondes*, and included criticisms on "pseudo-mathematicians," as well as numerous biographies of genuine men of science.

Of late years Bertrand communicated but few papers to the Paris Academy. He appears to have devoted himself chiefly to the administrative work of the Academy. In connection with the annual awards of

prizes, we find his name almost invariably appearing on the lists of judges, and he appears to have been no less energetic in drawing up biographical notices of deceased members. Nevertheless, we find him in 1895 writing on a geometrical theorem, and in 1896 breaking a lance with Boltzmann on that ever-fascinating and never-satisfying theory, the Kinetic Theory of Gases. This is the last time that we have been able to find Bertrand's name in the *Comptes rendus* as the writer of a paper, though it repeatedly figures in other connections.

Bertrand's countenance and carriage are described as "characteristic." He was "short, thick-set, lively, vigorous, and very kind-looking. His face was covered with scars, and his nose had lost its bridge," as we have seen, as the result of the Meudon railway accident, but the imprint of misfortune would appear to have given a tender pathos to his appearance, which seemed to draw his friends nearer to him. As a relaxation from work, he is said to have never tired of reading the novels of Sir Walter Scott, whom he described as "the greatest



Joseph Bertrand.
(From *La Nature*.)

novelist that ever lived." He leaves several sons, one of whom, M. Marcel Bertrand, a mining engineer, is himself a member of the Academy of Sciences, and rather well known.

If Bertrand's mathematical work earned for him the respect and admiration of men of science far and wide, his philanthropy endeared him to the smaller circle with whom he was more intimately known. The enjoyment he derived from his own studies was fully equalled by his delight at reading the works of others. He constantly sought to bring to light fresh workers, and the few words of kind reassurance and appreciation, not to mention the passing on of an idea or the lending a helping hand over a difficulty, so much valued by the budding mathematician, were never wanting at the critical moment. In endeavouring to help those less favoured by fortune than himself, Bertrand would give much time and thought as to the best way of rendering them assistance. In 1857 Baron Thénard founded the "Société des Amis des Sciences," an institution the object of which is to assist scientific men and their families when in need. Bertrand was one of the first to support the Society, and his signature figures along with those of Boussingault, Quatrefages, Becquerel, Sénarmont, Balard, Daubrée, Frémy, Deville, Berthelot and Pasteur in all its early records. In 1864 Bertrand was elected on the council, in May 1895 he was nominated vice-president, and in November of the same year he succeeded Pasteur as president. The Pasteur Institute also owes much to his energetic support.

Mathematical investigation is essentially a search for truth; but with Bertrand the love of truth and hatred of all that is false, was not confined to the mathematical side of his character; this trait was indeed deeply engrained into his whole existence. While there was nothing he would not do for those he knew to be deserving, he seems to have possessed a happy knack of effectually disposing of his enemies by a few strokes of sarcasm, which must have been the more withering because they so completely placed his adversaries in the wrong.

Had Joseph Bertrand's life and health been spared a little longer, there can be no doubt that he would have taken a foremost part in the liberal programme of congresses with which Paris hopes to attract a distinguished assembly of *savants* from all quarters of the globe, and we are sure that many English readers of his "Differential and Integral Calculus" would gladly have availed themselves of the opportunity of coming into personal contact with the well-known French mathematician. The loss of so prominent a figure in the Parisian world of science would at any time be deeply deplored, and his absence from the brilliant gatherings that are to be, only adds to our regret at losing one who has done much to simplify and popularise the study of mathematics.

At the funeral, discourses were delivered by M. Jules Lemaitre, director of the Académie Française; by M. Maurice Lévy, president of the Académie; by M. Berthelot, his fellow secretary of the Académie des Sciences; by M. Gaston Darboux, representing the Société des Amis des Sciences; by M. A. Cornu, representing the École Polytechnique; by M. Duclaux, director of the Institut Pasteur; by M. Gaston Paris, administrator of the Collège de France; and by M. Georges Perrot, director of the École Normale. In endeavouring to portray the life of a man of many and varied parts like Bertrand, we have largely drawn on the information contained in these orations, which are published in the *Comptes rendus*; but while it has thus been possible to enter into many of the details of Bertrand's life, his character as an individual can only be appreciated by reading separately the thoughts expressed by those who have known him intimately in his many capacities. Of these expressions, we can do no better than conclude with the words of M. Georges Perrot:—

"Il n'a pas été moins grand par le cœur que par l'esprit."

G. H. BRYAN.

NOTES.

WE notice with regret the announcement that the Duke of Argyll died on Tuesday morning, at the age of seventy-seven years. No definite arrangement has yet been made with regard to the funeral, but it is believed the interment will take place next week.

THE international conference for the protection of wild animals in Africa, announced last week, was opened at the Foreign Office on April 24, and was attended by plenipotentiaries of France, Germany, Great Britain, Congo Independent States, Italy, Portugal and Spain. Readers of NATURE hardly need to